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SOVIET SUBMARINE CABLES

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[Figures referred to are appended.]

It is important that submarine cables do not require the use of repeaters, or that the latter's number is at least reduced to a minimum over a long distance. The use of submarine repeater stations involves a number of difficulties in the construction and operation of cable lines. Submarine cables must be suitable for low-frequency as well as multichannel high-frequency communication over a long distance.

The insulating and external coverings of submarine cables must have a high moisture resistance. Cables must maintain high stability of electrical parameters during long operation in water. In calculating the mechanical durability of a cable, currents and water pressures at different depths must be taken into consideration. The shore cable must have a particularly strong protective armor casing against tides, anchors, boat hooks, and stones.

In recent years, the effort for developing submarine cables has gone into increasing the range of communication and expanding the band of frequencies transmitted. First of all, telegraphic communication was accomplished across water obstacles; only in the twenties was the laying of the first cable suitable for long distance telephonic communication begun.

The basic shortcoming of submarine telegraph cables is their unsuitability for high-frequency packing (multiplexing).

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The coaxial cable best meets the current requirement for high-frequency communication across large expanses of water. It should be noted that since submarine cable lines carry a frequency range of no more than 60-100 kilocycles, the symmetrical cable can be used with similar success for the same purpose. As far as expenditures for materials are concerned, however, the coaxial cable is 1.5 times more economical than the symmetrical, not to mention the possibilities of expanding the frequency range in the case of the coaxial cable.

The first coaxial marine cables, which were laid in 1920 - 1921, had an inner copper conductor activated by a ferromagnetic band. This increased the range of communication by cable, but at the same time limited the band of frequencies transmitted to the voice-frequency band (up to 3,000 cycles). Later, the use of loading coils was rejected in connection with the growing demand for increased communication, and the usual high-frequency coaxial cables began to be used.

A considerable increase in the amplification of the transmitting station and a reduction in the signal level at the receiving station are permissible in view of the isolated position of the cables and their protection from outside interference. Consequently, the attenuation which has to be covered for submarine cable lines can be reduced to 10 nepers; this value does not, as a rule, exceed 10 nepers for underground cables. High-frequency communication by cable can thus be realized with a distance of 150-250 kilometers between repeater points.

Compared to underground cables, the principal characteristics of the designs of submarine cables are as follows:

1. The dimensions of the submarine cable are larger; the diameter of the outer conductor of the underground coaxial cable does not exceed 18 millimeters, while it reaches 30-40 millimeters in the case of the submarine cable.

2. The current-carrying strands of the submarine cable have a flexible construction; the inner conductor consists of a wire with a large cross section and a wrapping of fine round wires or bands.

The outer conductor is made of flat bands or round wires. Figure 1 and the table below indicate standard constructions of coaxial submarine cables, and their dimensions and electrical data.

/See table on following page./

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Construction and Electric Data of Marine Coaxial Cables

	Inner Conductor			Dielectric		Outer Conductor			
		Wrapping or Bands of Wires							
No of Cable	Solid Conductor (diameter in mm)	No	Diameter or Thickness (mm)	Material	Radial Thickness (mm)	No	Diameter or Thickness (mm)	Attenuation at $f = 40$ Kilocycles, (Millinepers per km)	Characteristic Impedance (ohms)
I	2.51	10 wires	1.05	Rubber	6.35	48 wires	0.940	63.4	54.0
II	3.5	6 bands	0.36	Paragutta	5.70	6 bands	0.482	56.0	51.4
III	3.1	5 bands	0.40	Kargutta	4.35	34 wires	0.890	92.0	44.0

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3. A solid outside covering insulates the cable. Gutta-percha was preeminently used in the construction of the first cable designed for telegraph communication. Its merits are its high electric insulation qualities, excellent moisture stability, and good elasticity. The use of gutta-percha for high-frequency telephone communication is complicated by considerable dielectric losses in the band of high frequencies. The properties of gutta-percha also frequently deteriorate under the influence of atmospheric factors which complicate the storage and transportation of the cable.

Dielectrics possessing several more suitable properties than gutta-percha which find application in submarine coaxial cables include the following: (a) paragutta - a mixture of gutta-percha, purified wax, and deproteinized rubber; (b) karagutta - a mixture of gutta-percha and vaseline; and (c) a special rubber-like composition.

Polyethylene has been used as dielectric in recent constructions of submarine cables.

4. Special reinforced protective armor-covering protecting the center of the cable and giving it the tensile strength necessary for laying the cable and pulling it out in case of repairs.

Whether a cable is deep water or shore determines the nature of its armor. Deep water cables have an armor of round steel wires with a diameter of 2-5 millimeters. Steel with a high tensile strength is used.

For shore cables, the armor covering consists as a rule of two layers of round steel wires. The jute wrapping of the cable is processed in tannin; as a result, the jute does not contract in water.

Several of the most characteristic designs of submarine coaxial cables and their electric data are given below.

Cable Type 7/25

The flexible inner conductor of the cable consists of central copper strand with a diameter of 4 millimeters and a twining of copper wires with a diameter of 1.5 millimeters. The diameter of the inner conductor is 7 millimeters and the thickness of the polyethylene insulation is 9 millimeters. The outer conductor is made of copper wires with a plane cross section measuring 6 x 0.6 millimeters. Beyond it is a securing band of annealed copper. Then there is a protective cover of polyvinyl chloride, and then jute serving and an armor of steel wires with a diameter of 4-5 millimeters.

The shore section of the cable has a casing of wires with a diameter of 6 millimeters. A cable thread and chalk solution are over the casing.

The construction run of the cable reaches tens of kilometers.

The cable is packed in a range of up to 60,000 cycles. A frequency band of 300 to 3,000 cycles is set aside for voice-frequency telephony or for 12-18 channels of voice-frequency telegraphy. A band of 3,200 to 60,000 cycles is taken for six high-frequency telephone channels using an electric four-wire system (half of the band is used for transmission in one direction, and the second half for transmission in the reverse direction). The system of communication is single cable and the distance between repeaters is about 200 kilometers.

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There are analogous cable constructions which are loaded to 108 kilocycles in a two-cable system. In this frequency range, 24 high-frequency telephone channels can be realized. Telegraph transmission is also organized along high-frequency channels; up to 18 telegraph channels are realized in the place of one telephone channel.

Cable Type 11.6/43

The cable embodies three wires situated coaxially to each other and forming two coaxial circuits.

The first coaxial circuit consists of an outer and inner conductor and is used for multiple telephone-telegraph channels. An inner conductor of the first circuit and the central conductor of the coaxial cable make up the second circuit. This circuit is used as a control for operational and technical measurements, signaling, and service communication along the main line.

The cable has the following construction:

1. The central conductor consists of a copper conductor with a diameter of 1.7 millimeters and a twining of 10 copper wires with a diameter of 0.76 millimeter each. Beyond the conductor is a layer of polyethylene with an outside diameter of 11.22 millimeters.

2. The inner conductor consists of six spirally laid copper wires and of one reinforcing strip. The thickness of the inner conductor is 0.19 millimeter. The outside diameter of the inner conductor is 11.6 millimeters.

3. The insulation is complex. The inner conductor is wrapped spirally with a polyethylene cord with a diameter of 5.5 millimeters; the spirals are spaced 25.4 millimeters apart. A cylindrical polyethylene tube with an outside diameter of 43 millimeters is located upon the cord.

4. The outer conductor consists of six spirally arranged, copper strips with a thickness of 0.38 millimeters and of two open spiral coverings of broad copper strips with a thickness of 0.1 millimeter.

5. The protective armor cover consists of tarred jute serving, an armor of 23 wires, a compound layer, and an outside jute serving.

The weight of the cable is 11.8 tons per kilometer.

The shore cable, which is laid for a distance of up to approximately one kilometer from the sea, and also along the shore to the final repeater station, has a solid polyethylene insulation and a reinforced armor cover.

The characteristic impedances of the shore and submarine cable are made equal by increasing the inside diameter of the shore section by approximately 20 percent.

The difference between the underground and the shore part of the cable is in the use of lead sheathing and armor band instead of wire armor wrapped around the cable. The characteristic impedance of the submarine cable is 62 ohms. The attenuations of the cable are given in Figure 3.

The design of the submarine, shore, and underground parts of Cable Type 11.6/43 is shown in Figure 5.

[Figures follow.]

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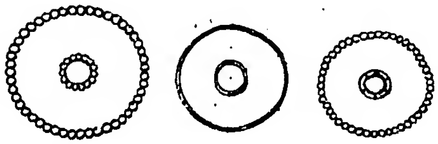

Figure 1. Construction of Coaxial Submarines Cable

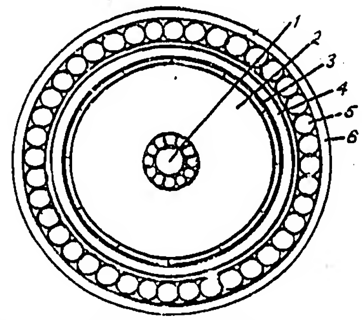

Figure 2. Coaxial Submarine Cable Type 7/25
1. Inner conductor (copper); 2. Insulation (polyethylene); 3. Outer conductor (copper); 4. Protective sheath: 5. Armor (steel); 6. Jute

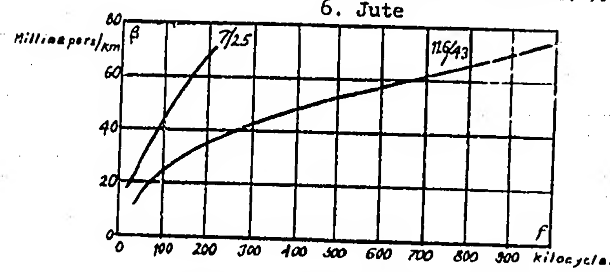

Figure 3. Attenuation per Kilometer of Coaxial Submarine Cables

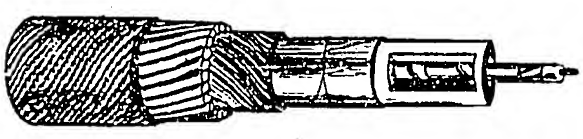

Figure 4. Over-all View of Coaxial Submarine Cable Type 11.6/43

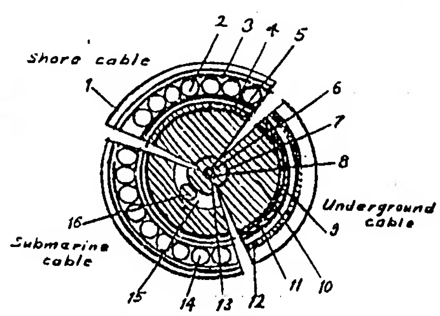

Figure 5. Design of Submarine Cable Type 11.6/43
1. Two layers of jute; 2. Wire armor; 3. [Sealing] compound; 4. Two layers of jute; 5. Outer conductor; 6. Central conductor; 7. Inner conductor; 8,9,10. Polyethylene insulation; 11. Lead sheath; 12. Armor band; 13. Polyethylene insulation; 14. Wire armor; 15. Airgap; 16. Polyethylene cord

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